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Can EDA vendors deliver on their big promises?

A CAHNERS PUBLICATION

Electronic Business®

FOR THE MANAGEMENT TEAM IN ELECTRONICS, COMPUTER, AND SYSTEMS COMPANIES WORLDWIDE

DECEMBER 9, 1991

SPECIAL REPORT

An ambitious Taiwan beckons U.S. electronics

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As the world's seventh-largest producer of electronic products, Taiwan is no longer content to be just another clone maker. The nation has set its sights on the design and production of more higher-value products. The good news is that for the growing number of U.S. electronics companies seeking a leg up in the booming Pacific Rim marketplace, Taiwan may become a key foothold for them

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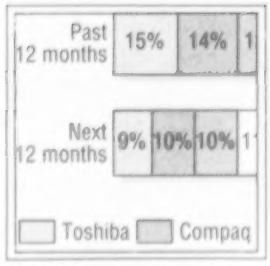

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Opportunity and crisis along the Pacific Rim

Senior editor
Peter Burrows

PERSPECTIVE can be everything. A perfect example is the Chinese ideogram that can be read as either "crisis" or "opportunity." We've all read about the crisis of competition from Asian electronics companies; this issue of ELECTRONIC BUSINESS focuses on the opportunities for U.S. companies in forging partnerships along the Pacific Rim.

Many of the partnerships are taking root in Taiwan, where quick-paced technological development, fired by an intense entrepreneurial spirit, is reminiscent of another island nation—mid-20th-century Japan. In our cover story, senior editor Rick Whiting tells how Taiwanese companies, unwilling and economically unable to rely on sales of low-capacity chips or computer clones, are reaching out to U.S. companies for the design and marketing expertise needed to compete as vendors of high-end processors and systems.

The evolution of Korea's electronics industry, meanwhile, creates almost a reverse image of our own. Korea's remarkable growth began with strong government intervention. As the growth curve flattens, however, Korean executives are looking for more private initiative.

Closer to home, previously high-flying vendors of electronic design automation software are feeling the drag of a cyclical crisis familiar to other electronics sectors: Technical innovation yields quick growth and high profit margins for a few companies, which encourages capital investment and spawns a host of competitors. As the market matures, the gap between yesterday's innovation and today's business needs develops. Sales growth slacks off, margins shrink, financing dries up, and vendors vanish. EDA vendors are learning to differentiate themselves from the competition, says senior editor Peter Burrows in his market report, by the quality of their customer relationships.

The best thing, of course, is to create one's own opportunities. West Coast associate editor David Webb describes how AT&T and Xerox are nurturing innovation by forming and funding R&D subsidiaries. The goal is to keep promising technology from leaving the company, even if it is considered off the beaten path of its business strategy. But you don't have to be a Xerox or an AT&T to learn from these model programs: There are a number of incentives a midsize company can offer to keep its best and brightest on board.

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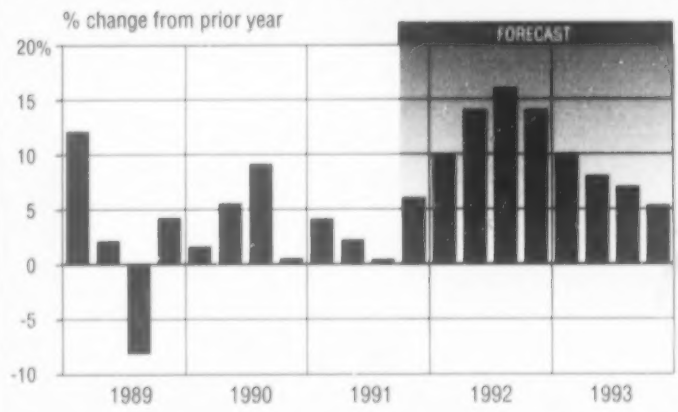
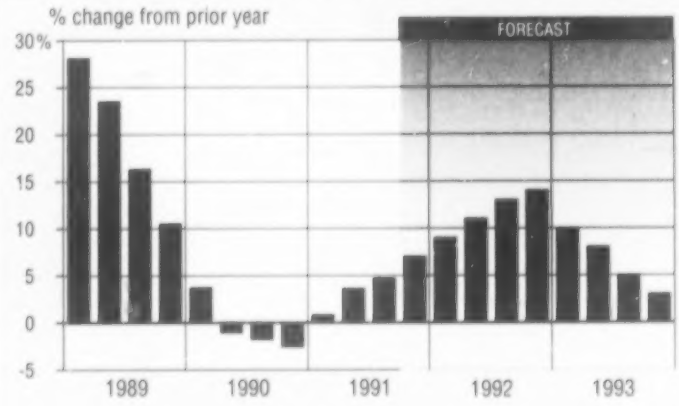
BPA ABP

Semiconductor orders growth is feeble in 1991...



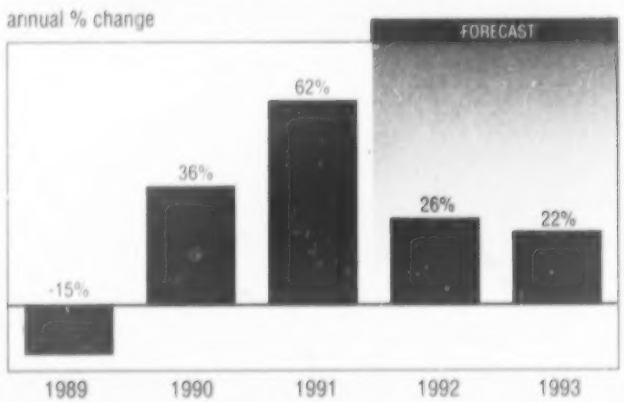
Source: Semiconductor Industry Association; forecasts: Cahners Economics

...as sales recover slightly from 1990 losses...



Source: Semiconductor Industry Association; forecasts: Cahners Economics

...thanks to strong growth in microprocessors



Source and forecast: Semiconductor Industry Association

Microprocessors drive chip recovery

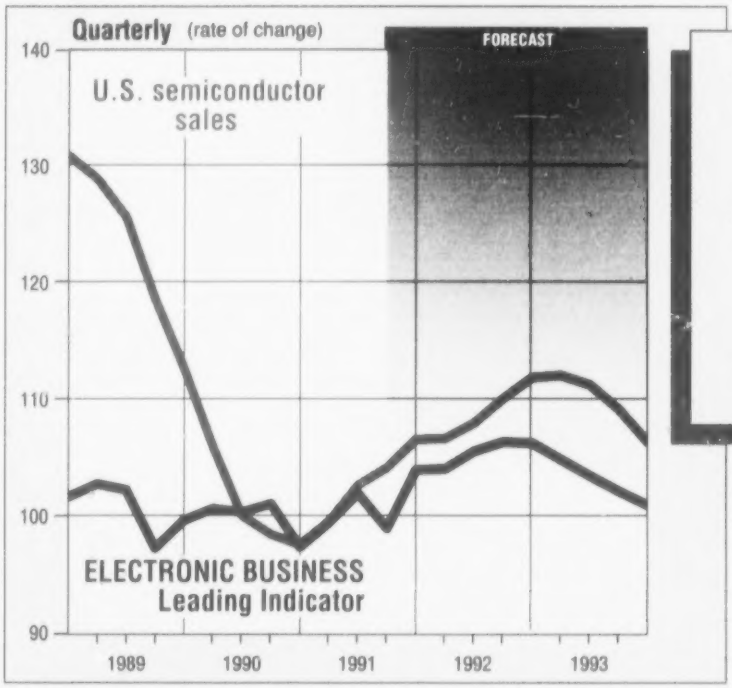
SLUGGISH, WEAK, AND flat. That's how semiconductor execs have been describing their sales recently. The summer slowdown, coupled with a weak economy, pushed semiconductor sales to the U.S. market up only 4.8% in the third quarter of 1991 compared with a year ago, significantly below Cahners' previous expectation of 9.5% growth. Semiconductor sales increased faster than orders this past summer, suggesting the industry is cutting into its backlogs. The slowdown in orders growth has persisted for nearly two years. New orders inched up a meager 0.4% in the third quarter of 1991. All that has left the industry skeptical about a recovery materializing any time soon.

Fortunately, strong growth in microprocessors has boosted the market this year and will assist next year. Compared with other semiconductor markets such as memory, which rose only 6% for the 12 months ended in August 1991, microprocessor sales to the U.S. swelled 41.6%, to $1.31 billion, during that same 12-month period. Because the U.S. consumes 44% of all microprocessors, the U.S. outlook will mirror that of the worldwide market. The Semiconductor Industry Association predicts worldwide sales of microprocessors will skyrocket 62% this year and 26% in 1992. While most microprocessors can be found in computers, embedded controls, and autos, home appliance makers are eating up these chips now, too.

Watch for continued growth in semiconductor sales as falling interest rates eventually foster increased investment in capital equipment. With consumption of computers and office equipment increasing, demand for semiconductors will rise accordingly next year. Our forecasts call for semiconductor sales to the U.S. to climb a relatively slow 11.9% in 1992 to $17.2 billion.

—Julie Handelman

ELECTRONIC BUSINESS Leading Indicator

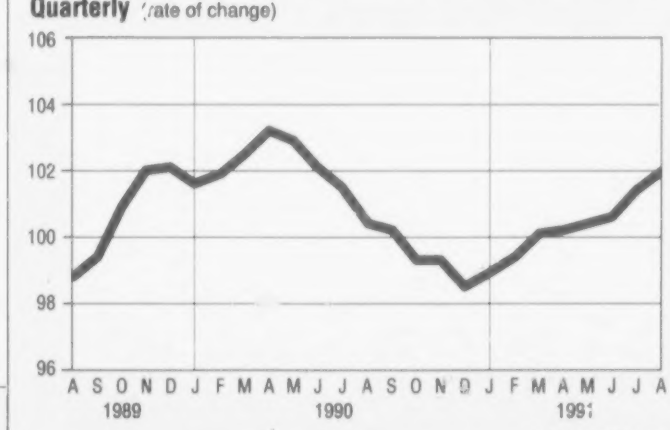


Leading Indicator slumps in September

THE ELECTRONIC BUSINESS Leading Indicator (EBLI) slumped for the third consecutive month in September at 98.7, a trend that may be indicative of slow industry growth ahead. The lack of a convincing EBLI recovery up to this point has pushed the next expected EBLI peak out to September 1992 at 106.9, three months later than our previous forecast.

EBLI is a weighted composite of six statistics that lead activity in the electronics industry. To obtain a complimentary background paper, contact Cahners Economics, 275 Washington St., Newton, MA 02158-1630, USA; telephone (617) 630-2119; fax (617) 630-2100.

Semi workers' weekly hours grows steadily



Source: Labor Dept.

	Latest month	Previous month	Year ago	1990 average
ELECTRONIC BUSINESS Leading Indicator (rate of change, Sept.)	98.7	98.9	101.0	99.9
U.S. semiconductor bookings ($ millions, 3-month average, Sept.)	$1,209	$1,206	$1,179	$1,254
Weekly hours of semiconductor production workers (monthly average, Aug.)	40.7	40.2	39.4	40.4
Electronic components lead time index (1977 = 100, Oct.)	89.9	81.4	64.0	80.7
S&P's semiconductor stock price index (1970 =10, monthly average, Sept.)	66.4	72.3	56.7	64.6
Change in electronic components inventories ($ millions, SA, Aug.)	-$90	$48	-$181	$33
Contracts and orders for plant and equipment ($ billions, SA, Aug.)	$34.1	$40.3	$35.6	$38.6

SA = seasonally adjusted; all other data are not seasonally adjusted

Sources: Semiconductor Industry Association, Bureau of Labor Statistics, *Electronics Purchasing* magazine, Standard & Poor's, Commerce Dept., Bureau of Economic Analysis, Cahners Economics

An ambitious Taiwan beckons U.S. electronics partners

By Rick Whiting

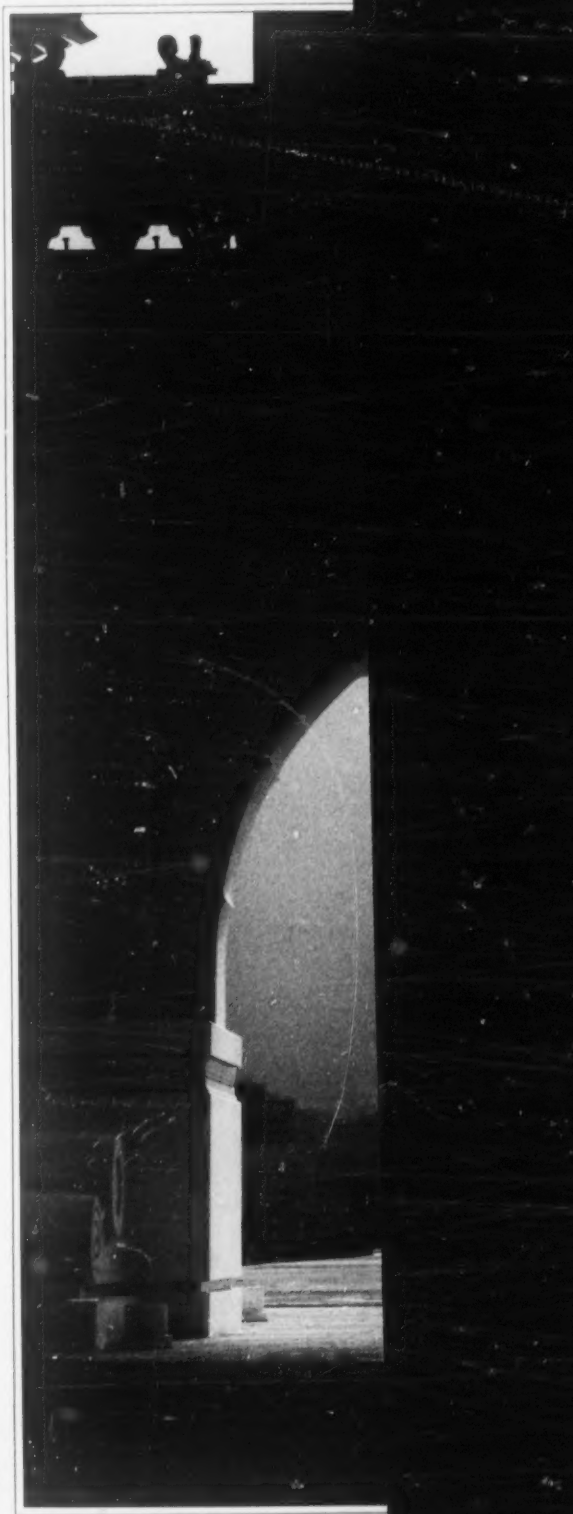
No longer content to be just another clone-maker, the nation has targeted high-value markets. That will call for some sophisticated industry allies

After years of producing PC clones, low-capacity DRAMs, and chips for electronic toys, Taiwan's electronics industry is being wrenched by change. Like Japan in the 1970s, Taiwan R.O.C. (Republic of China) has set its sights on the design and production of such higher-value products as application-specific ICs (ASICs), static RAMs, and liquid crystal displays (LCDs).

At the same time, Taiwanese producers of computers and peripherals are also moving upscale. Battered by plummeting profit margins and cutthroat markets, manufacturers have targeted palmtop and notebook computers, workstations, and X terminals.

All of that is good news for the growing number of U.S. electronics companies seeking a leg up in the booming Pacific Rim marketplace. The reason is that, in order to reach those goals, Taiwan needs corporate partners with expertise in electronic design automation (EDA), local area networks, wireless communications, system software, systems integration, multimedia, and other technologies. Selling those products, moreover, demands know-how in marketing, international distribution, and customer-support networks.

Taiwan is already the world's seventh largest producer of electronic products, behind the U.S., Japan, Germany, Britain, France, and Singapore. Overall, Taiwan's two-way trade worldwide skyrocketed from $3 billion in 1970 to $121 billion in 1990. The nation exported nearly $8 billion worth of electronic goods last year, including $5.9 billion in computer sys-



A gateway frames the Chiang Kai-Shek memorial in Taipei

Manfred Gottschalk/West Light

tems and peripherals and $1.2 billion in semiconductors. Also last year, Taiwan shipped computers and related peripherals valued at $2.32 billion to North America—mostly to U.S. OEMs that resell the products under their own labels. Semiconductor exports to the U.S. reached $378.1 million in 1990.

ALTHOUGH TAIWAN'S IC industry is well established, however, "we still have a long way to go to catch up with Japan, the U.S., and even Korea," says David C. Hsing, general director of the Electronics Research & Service Organization (ERSO), a government agency charged with upgrading Taiwan's semiconductor production capability. Taiwan's IC production exceeded $1.57 billion in 1990.

Company executives and government officials say that U.S. companies have what Taiwan needs. In return, the nation claims to offer:

- Advanced semiconductor production facilities that U.S. chip makers can use to gain time-to-market advantages and avoid building costly fabs on their own;
- A highly skilled and educated work force familiar with the business style of U.S. companies and the quality culture of Japanese vendors;
- Low-cost capital and government incentives to develop and produce high-end electronics products in partnership with Taiwanese companies;
- A base from which to penetrate the Pacific Rim, economically the fastest-growing region in the world.

While the Texas Instruments Inc.-Acer Inc. alliance to produce DRAMs has garnered a lot of attention, a long list of smaller U.S. companies, such as Seeq Technology Inc. and Chips & Technologies Inc., have established partnerships in Taiwan. As more U.S. semiconductor companies opt to go fabless, observers predict the number of U.S. companies seeking alliances in Taiwan will grow.

For U.S. vendors looking for new sales turf, the evolution within the Taiwanese electronics industry is creating potential markets for everything from digital-signal processors and connectors to EDA software and test equipment. In 1990, for example, local manufacturers could supply only 13% of the $2.6 billion in semiconductors needed by Taiwanese PC companies and other manufacturers; the rest were imported, with 34.6% of those imports coming from the U.S.

Western Digital Corp. counts some 30 Taiwanese notebook PC makers as customers for

its core logic chipsets, video and storage controllers, and disk drives. Teradyne Inc. has sold analog, digital, and memory test equipment to several Taiwanese semiconductor manufacturers and in August sold a memory test system valued at more than $1 million to ERSO. Synopsis Inc., a vendor of electronic design software that set up shop in Taipei a year ago, now lists PC maker Acer, chip manufacturer United Microelectronics Corp., and ERSO as customers.

TAIWAN MAY ALSO APPEAL to U.S. electronics companies because of its business climate and culture. Taiwanese companies "are a lot more like U.S. companies than those in other [Pacific Rim] countries," says Ken Lindsay, Asia/Pacific business manager for Valid Logic Systems subsidiary IMS, which counts most major Taiwanese semiconductor manufacturers among users of its IC design debugging software. Given the influence of the large number of U.S.-owned subsidiaries in Taiwan, executives tend to follow strategies and management styles similar to those of their U.S. counterparts. Reinforcing the similarities is the fact that there are some 30,000 Taiwanese engineers now working for electronics companies in California and many more in Taiwan that once worked in the U.S.

Unlike Japan and Korea, whose electronics industries are dominated by a handful of huge conglomerates, Taiwan provides a more hospitable business environment for U.S. vendors because the country's electronics industry is made up largely of small companies eager for—and more in need of—strategic alliances with Western companies. Tatung Co., Taiwan's largest electronics corporation, reported sales of just more than $1 billion in 1990, and Taiwan's top 10 electronics companies had combined sales that year of $3.4 billion. That barely exceeds the sales of Japan's Nintendo, ranked 16 on ELECTRONIC BUSINESS's list of Japan's top 50 companies. Samsung Electronics, Korea's largest electronics company, had 1990 sales of $6.37 billion.

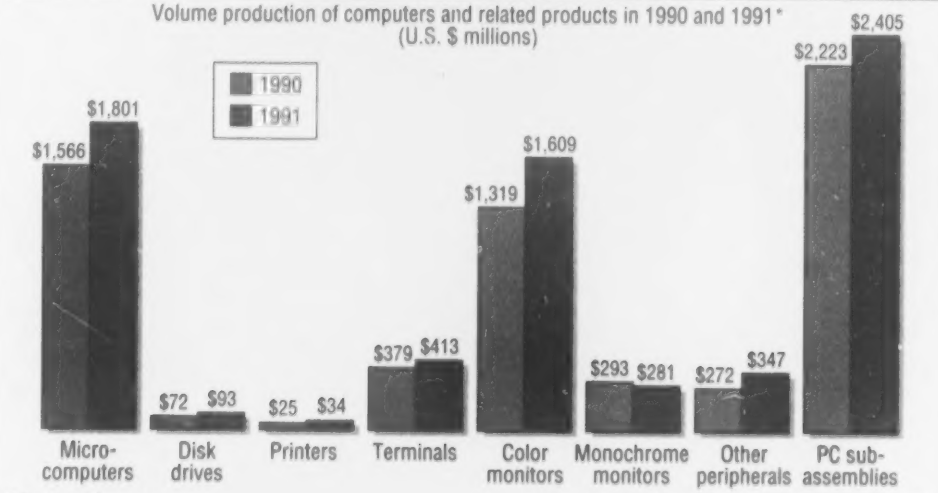
Critical to achieving success within the Taiwanese electronics market is viewing it as a place to establish strategic relationships. Taiwanese companies are looking for partners, not just vendors.

"You've got to come in with a technology they can turn to their own use," says Harry Sello, a Menlo Park, Calif.-based technology licensing consultant. "Use the technology to penetrate the market. There are opportunities for U.S. companies in Taiwan as long as they are willing to team up and meet the Taiwanese desire to become independent and a force within the worldwide IC industry."

Many companies make use of local distributors to help generate sales leads. But successful companies do not rely solely on third parties for customer service, preferring to work directly with customers—either through frequent visits or a permanent support staff. Both Western Digital and LSI Logic Corp. maintain

What Taiwan makes

Volume production of computers and related products in 1990 and 1991* (U.S. $ millions)



*Projected

Source: MIC

design centers in Taipei where they work with customers to incorporate their products into Taiwan-built PCs and computer boards.

"It takes a while to build up trust and develop a working relationship," says John Lee, director of consumer products at The DSP Group Inc. in San Jose, which markets digital-signal processor chipsets to Taiwanese manufacturers of digital answering machines and cordless phones.

JAPANESE VENDORS HAVE made gains against U.S. companies in some Taiwanese markets by offering customers extensive training, on-site support, and rapid response time, says Howard Young, vice president and cofounder of California Quartz Inc., a San Jose marketer of quartzware products used in chip fabrication. Japanese competitors have already overtaken U.S. companies in selling photolithography equipment in Taiwan, says Paul Callendar, director of Asian sales for etching equipment vendor Lam Research Corp. in Fremont, Calif. Lam, Callendar says, is putting more emphasis on direct sales in Taiwan.

Taiwan, however, is not a place for U.S. companies seeking cheap labor for manufacturing or assembly. The country's unemployment rate hovers around 2%, and there is a shortage of unskilled labor. Within the manufacturing sector, the average hourly wage has reached $3.70—low compared with $10.66 in the U.S., but higher than Malaysia, Thailand, and mainland China (to which even several Taiwanese companies have recently moved their labor-intensive manufacturing operations).

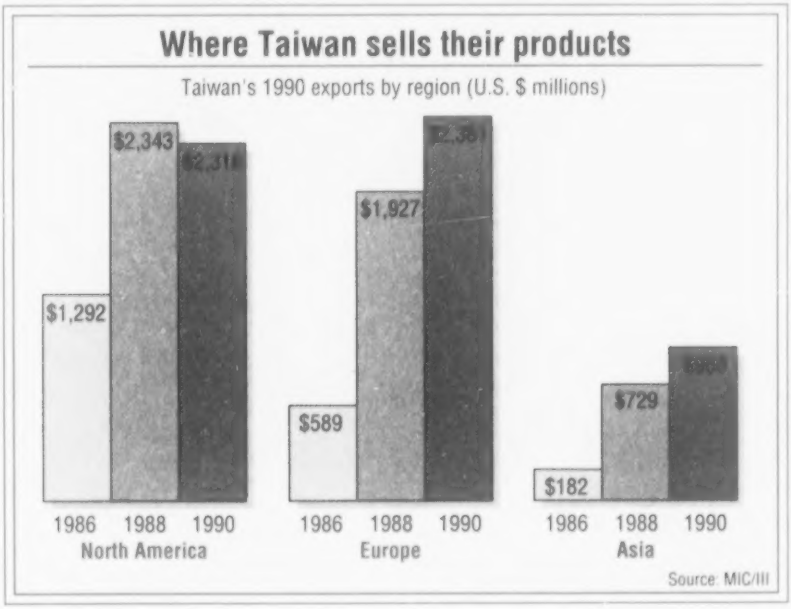
THE RAPID GROWTH OF Taiwan's electronics industry has also boosted demand for engineering talent. Job-hopping by the best and brightest resembles that of Silicon Valley in its early days. Hiring experienced engineers will not come cheaply for U.S. companies establishing local subsidiaries or service/support centers.

U.S. companies seeking customers and partners in Taiwan face other problems. Distribution and support are particularly difficult given the plethora of small, emerging companies in the country, says Mike Burger, National Semiconductor Corp.'s Asia sales director. Also, buying patterns among the small companies quickly rise and fall with the economy, making the electronics market very cyclical.

Doing business in Taiwan has other idiosyncrasies. Taiwanese businessmen are "fierce negotiators" and will take their time when it comes to striking a deal, says one U.S. chip company executive; and while having the lowest price was all that was once needed to win a sale in Taiwan, California Quartz's Young says quality is becoming a factor in Taiwanese corporate buying decisions.

Other U.S. executives with experience in Taiwan are critical of the country's business culture, saying Taiwanese business people often take a very short-term outlook in their planning and focus on making a quick profit "These guys would just as soon be selling shoes if there were as much money in it," says one observer who asks not to be named.

As proof, several observers point to the low level of investment Taiwanese electronics companies make in R&D. Even the cream of Taiwan's electronics industry—the chip and computer companies in the sprawling



Acer CEO Stan Shih: "Many, many opportunities" for U.S. companies

Hsinchu Science Industrial Park southwest of Taipei—spend less than 5% of sales on R&D, versus 9% average among U.S. electronics companies.

Protection of intellectual property remains an issue for U.S. companies doing business in Taiwan. Last year the Taiwanese government instituted a number of copyright and patent protection laws for software and semiconductors in an effort to improve the business climate for foreign companies.

"Yes, they have put laws on the books, but to my mind, those laws are not being sufficiently enforced," says consultant Sello. "I would suggest extreme caution in how your technology is being used." He and other Taiwan watchers point to software and ASIC designs as being particularly sensitive areas.

TAIWAN REMAINS VERY protective about its own technology, however. Earlier this year, an agreement between AT&T and the Taiwanese government's Industrial Technology Research Institute (ITRI) to cross-license semiconductor, optical, computer, and superconductivity technology was put on hold. An AT&T spokesperson says that Taiwan's laws need modification to give ITRI the authority to sign the agreement, but a source says the deal was sidelined by Taiwanese government officials who considered their technology to be proprietary.

Indications are that efforts by Taiwan companies to link up with foreign companies will increase. In early 1991, Taiwan's China External Trade Development Council began the trade opportunity project in which the agency will play matchmaker between Taiwanese companies and foreign companies seeking joint ventures or technology transfers. The major effort is in electronics and information systems, according to project manager Fred M. C. Chang. He hopes to establish some 30 to 40 alliances each year.

Despite the crash of Taiwan's stock market

Taiwan provides springboard for Pacific Rim expansion

IN ADDITION to being a place for U.S. electronics companies to do business, Taiwan can also serve as a jumping-off site for vendors looking to expand into mainland China and other Pacific Rim countries.

Working in Taiwan's favor is its geographic location, roughly in the midst of the Asia/Pacific region. Japan and South Korea are to the north, Singapore to the south, and Hong Kong and mainland China a short plane ride away. Other developing nations, such as Malaysia, Thailand, and the Philippines, lie to the south.

"If you're an American company and you want to be in the Pacific Rim and want to push into China, I would be in Taiwan," says Dan Heyler, a Taiwan-based analyst for Dataquest Inc.

With Hong Kong, the region's traditional crossroads, slated to revert to Chinese control in 1997, some Taiwanese corporate executives and government officials quietly mention the island nation as an alternative. They also acknowledge, however, that they have seen little evidence of movement of capital or corporations from Hong Kong to Taiwan. Others suggest that Singapore will inherit Hong Kong's role in the region, given its base of financial service companies.

But Taiwanese companies have been establishing themselves throughout Asia, including mainland China. Economists estimate that Taiwan-China trade alone will reach $5 billion this year. In September, Taiwan even began discussing economic ties with Vietnam, and Taiwanese telecommunications vendor Taicom is close to establishing a joint venture with the communist country's Telecommunication Bureau.

Partnerships with such adventuresome Taiwanese companies can boost the fortunes of U.S. companies looking to expand across the region. "Taiwan can be a good partner in marketing and selling in this area," says John Hsuan, president of United Microelectronics Corp. □

last year, Taiwan remains a cash-rich country with some $75 billion in foreign exchange reserves, second in the world only to Japan. Low-cost capital is still plentiful from both private and government sources, although banks appear more cautious in their lending than they were during the late 1980s.

Under the Statute for Upgrading Industries tax law, which took effect last Jan. 1, companies can receive tax credits of 5% to 20% for investments in automated production equipment or technology and for R&D outlays. The government is also willing to sponsor up to 50% of development costs for advanced products or provide loans for R&D. Those incentives are available for Taiwan-based subsidiaries of foreign companies as well as for native companies.

ERSO is in the midst of a five-year, $289 million program to expand Taiwan's submicron semiconductor manufacturing capability, and the project is providing U.S. companies with opportunities. Because ERSO serves as a training ground for many semiconductor engineers in Taiwan, companies that sell production equipment to the agency are, in effect, developing a future customer base. In addition to selling ERSO test equipment with a $1 million price tag, Teradyne is jointly developing advanced test technology with the government agency. Applied Materials Inc. is doing the same in vapor deposition.

Also working in favor of U.S. companies is Taiwan's desire to lessen its dependence on Japan for semiconductors, components, and other electronics products. A growing trade deficit with Japan, combined with a historical antipathy for the Japanese (Japan occupied Taiwan for 50 years until the end of World War II), is fueling the move toward partnering with, and buying from, companies from outside Asia. "If they could find a good source of supply from Europe or the U.S., most Taiwanese companies would prefer it," Chang acknowledges.

Taiwan's computer industry in perspective

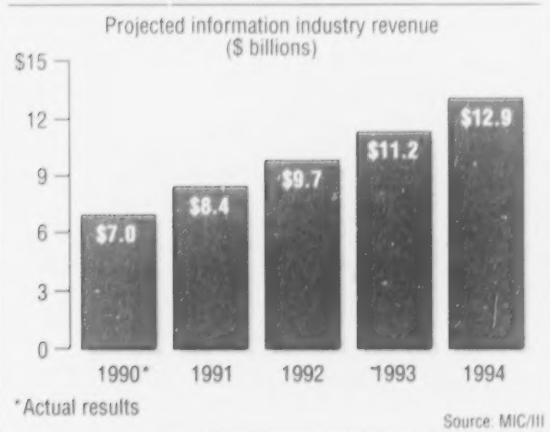
	1986	1988	1990
Total production (in U.S. $ millions)	$2,134	$5,324	$6,149
Information technology (as a % of Taiwan's GNP)	2.7%	4.2%	3.8%
Computer products exports (in U.S. $ millions)	$2,063	$5,152	$5,873
% of worldwide information technology market	1.5%	3.1%	3.0%

Source: ERSO

IN THE COMPUTER ARENA, less government intervention rather than more may provide the opportunities. Taiwan's government has, in recent years, been aiding efforts by Taiwanese companies to develop notebook PCs, workstations, X terminals and other products. Using funds chipped in by the companies, the government Computer and Communications Research Laboratory has developed base technologies that the participating companies use to build products. There is, however, a growing sense among both vendors and government officials that that approach only encourages companies to build clone products with little or no added value.

Industry leaders such as Acer chief executive Stan Shih advocate what he calls "vertical consortia," in which companies ally themselves with suppliers of graphics boards, networking technology, and software to provide customers with more feature-rich systems. "There are many, many opportunities to link together," says Shih. □

Taiwan's growing information products industry



The China External Trade Development Council maintains a New York office. Phone (212) 532-7055; fax (212) 213-4189.

U.S. chip makers trade know-how for capacity

In return for their state-of-the-art design, U.S. companies get access to well-heeled foundries that will produce half-micron semiconductors next year

By Rick Whiting

Taiwan's semiconductor industry is trying to move upscale, and it needs help from U.S. companies to do it.

Because Taiwan's PC clone and consumer electronics manufacturers have traditionally been the driving force behind the country's semiconductor industry, chip makers have concentrated on manufacturing such commodity products as low-capacity DRAMs and chips for electronic toys. Now, facing competition from other Asian countries, Taiwan's chip industry must change. "Taiwan cannot compete with Japanese or Korean companies in volume commodity businesses," says John Hsuan, president of semiconductor maker United Microelectronics Corp. (UMC).

Taiwanese semiconductor companies are attempting to expand into such niche markets as application-specific ICs (ASICs), semiconductors for telecommunications and modems, static RAMs, image compression chips, and liquid crystal displays (LCDs).

In order to make that move, Taiwanese engineers need technology and customer application expertise from U.S. companies, says Don Brooks, one-time Fairchild Semiconductor chief executive and now president of Taiwan Semiconductor Manufacturing Co. "There's no leadership in Taiwan for these guys to learn from," he says. "Taiwanese engineers may be adept at executing new designs. Where they miss the boat is knowing what to design."

Altogether, there are more than 60 semiconductor companies in Taiwan, though only eight companies operate fabrication plants (start-up Macronix International Co. will make nine) with the rest limited to design work. Taiwan's semiconductor industry, largely concentrated in the Hsinchu Science Industrial Park southwest of Taipei, enjoyed a 27% compounded annual growth rate between 1986 and 1990. Production reached $1.57 billion last year, including design, manufacturing and packaging operations, and exports reached $1.19 billion, of which 31.8% went to the U.S., 18% to Europe, and 11.6% to Japan.

San Jose-based Seeq Technology Inc. is trading its flash memory designs for the foundry capacity of Hualon Microelectronics Corp. (HMC). By moving its volume production of electrically erasable programmable read-only memory (EEPROM) chips and Flash EEPROMS to HMC's Hsinchu plant, Seeq gains access to production facilities the company's managers could only dream of before.

"My own internal capacity was hitting a wall at 1.5 microns," says Seeq chairman and chief

TSMC president Don Brooks: "There's no leadership in Taiwan for these guys to learn from"

executive J. Daniel McCranie. Building the 1 micron fab that Seeq needed would have cost $300 million—and Seeq's annual sales are only in the range of $350 million a year.

HMC began producing Seeq's 1.2 micron EEPROMs in October, a little more than one year after the two companies formed their partnership. The companies are now developing 1 micron EEPROMs and plan to move to 0.8 microns in the future. Plans also call for HMC to manufacture analog parts for Seeq's Ethernet product line and the companies will jointly develop Extended Industry Standard Architecture-based Ethernet data link controllers and 10BaseT analog chips.

The Seeq-HMC partnership goes beyond contract manufacturing in that HMC bought a 10% stake in Seeq to secure the long-term relationship. HMC also has non-exclusive rights to sell products based on Seeq designs, although McCranie says HMC cannot use Seeq technology or processes without permission.

Semiconductor manufacturing in Taiwan

	1987	1988	1989	1990
Number of manufacturers	3	6	6	8
Revenue (U.S. $ millions)	$119	$154	$284	$337
Growth rate	25%	29%	84%	19%
Process capability (in microns)	2.0	1.5	1.2	1.0
R&D spending as % of sales	NA	NA	10.0%	11.1%
Taiwan semiconductor consumption (in U.S. $ billions)	1.5	1.8	2.2	2.5

*NA = not available

Source: ERSO

THE NEWEST PLANT in Hsinchu is the result of a $350 million joint venture between Texas Instruments Inc. and Taiwan PC manufacturer Acer Inc. The companies will split the plant's projected output of more than one million DRAMs per month, with Acer using its share in its own computers while TI sells its share on the open market. Acer gains a steady supply of DRAMs free of price fluctuations while TI gains fabrication capacity with minimal risk or capital investment.

Even though the facility was formally dedicated on Sept. 26 in a ceremony presided over by TI chairman Jerry Junkins and Acer Inc. chief executive Stan Shih, the plant actually began pilot production of 4-megabit DRAMs in July. Volume manufacturing is slated to begin early next year and future plans call for producing both ASICs and 16-Mbit DRAMs. The facility has 0.8 micron CMOS capability and will be upgraded to 0.5 microns by the end of 1992.

Acer and the China Development Corp. provided most of the plant's funding and together hold a 74% stake in the TI-Acer venture. TI is providing the advanced 4-Mbit and 16-Mbit DRAM technology. Acer also brings plant management experience to the party while TI is providing training for plant engineers.

AS A PURE FOUNDRY, TSMC devotes 100% of its capacity to building products for other companies. Brooks says that TSMC is currently manufacturing mixed analog-digital chips, digital logic, SRAMs, erasable programmable read-only memories (EPROMs) and other semiconductors for some 50 customers, both Taiwanese and foreign companies.

TSMC's major customers include NV Philips, which holds a 27% stake in the company, and Advanced Micro Devices Inc. Philips and AMD have both transferred process technology and designs to TSMC. The Hsinchu-based company is also working with Chips & Technologies Inc. on microprocessors and other projects that Brooks declines to discuss and has licensed gate array designs from VLSI Technology Inc., another customer.

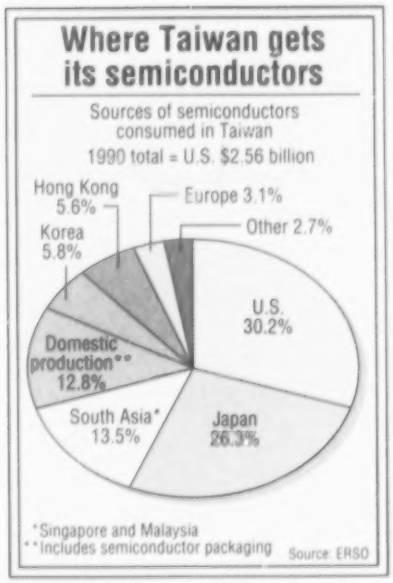
UMC's partnerships with U.S. companies began in 1985 through a deal with TRW Inc. to manufacture echo cancellation chips for telecommunications applications, a partnership that gained UMC access to TRW's 1.25 micron technology. The two companies have since expanded their relationship to include manufacture of analog-digital converters. Hsuan is closed-mouth about UMC's other relationships.

UMC dedicates 20% of its Hsinchu foundry capacity to contract manufacture work and Hsuan says the demand for contract manufacturing is increasing. UMC is also converting part of its oldest fab for manufacturing thin-film transistor LCDs on a contract basis for U.S. companies. Hsuan acknowledges that jumping into LCDs, a technology largely dominated by Japan, is risky, but trade friction between the U.S. and Japan over LCD screens could provide the company with a major opportunity. UMC hopes to begin pilot LCD produc-

tion in the fourth quarter of 1992.

Not all U.S.-Taiwanese semiconductor partnerships have been happy marriages. Intel Corp. had deals with both TSMC and UMC that went sour. TSMC was to have manufactured 256-Kbit and 1-Mbit DRAMs for Intel, but Intel pulled out earlier this year—presumably because DRAM prices were skidding. Brooks will say only that the partnership was ended by mutual decision.

UMC and Intel were to have jointly produced 4-Mbit and 8-Mbit flash EEPROMs under a contract signed in November 1990. But Intel, Hsuan says, wants fabrication equipment to be dedicated to Intel products while UMC wants to use the excess capacity when Intel products are not rolling off the line. Hsuan will only describe the partnership as "on hold."



Macronix is cited by some as *the* up-and-coming semiconductor company in Taiwan. Founded by Taiwanese engineers who worked in the U.S., Macronix, in fact, considers itself a U.S. company and maintains its headquarters in San Jose. A recent Dataquest report cites Macronix as an example of a Taiwanese company "that has distinguished itself by adopting a more global view" and making plans for long-term profitability. Macronix has raised some $80 million in venture funding and is completing the first phase of what may be the most advanced fabrication facility in Hsinchu. □

Major players in Taiwan's semiconductor industry

Company	Process technology (microns)	Monthly production	Date of operation	1989 revenue ($ millions)	1990 revenue ($ millions)
United Microelectronics	1.5-5.0 CMOS	4-inch wafers 40,000	1/82	$117.4	$148.7
	1.0 CMOS	6-inch wafers 15,000			
Taiwan Semiconductor Manufacturing	1.5 CMOS	6-inch wafers 12,000	7/87	72.0	84.4
	1.0 CMOS	6-inch wafers 10,000			
Winbond Electronics	1.0-5.0 CMOS 1.0 BiCMOS	5-inch wafers 20,000	10/88	37.9	48.3
Hualon Microelectronics	1.0 CMOS 1.2 NMOS	5-inch wafers 25,000	7/88	45.5	44.6
Advanced Device Technology	2.5-5.0 CMOS	4-inch wafers 15,000	1/86	7.6	5.6
Advanced Microelectronics Products	2.0-5.0 CMOS	4-inch wafers 10,000	10/88	3.8	5.6
Unique Technology Integrated Circuit	2.0 CMOS 3.0 BiPolar	5-inch wafers NA	9/90	NA	NA
Holtek Semiconductor	2.0 CMOS	5-inch wafers NA	12/90	NA	NA

*NA = not available

Source: ERSO

EDA vendors learn a painful lesson

Faulty software and poor service slowed the growth of the $3 billion electronic design automation market this year

By Peter Burrows

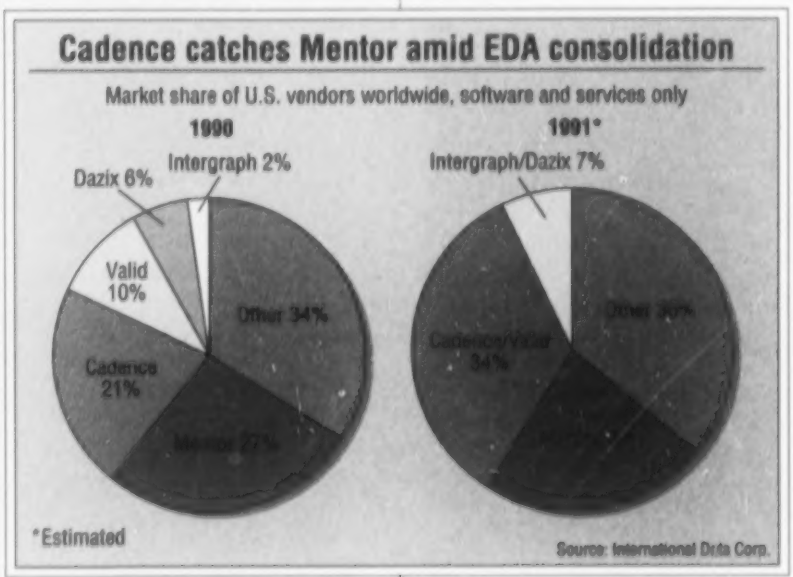
With growth rates sagging for the first time in the industry's 10-year history, the technology-minded vendors of electronic design automation (EDA) software are getting more serious about satisfying their customers' full range of needs. To overcome a tough economy, product maturity in many key markets, and a more skeptical customer base, vendors are developing a broader vision of their business to make sure their products deliver on their well-hyped potential.

"It used to be that the vendors could sell any tool that was a little better than its predecessor, and they didn't have to be very attentive to particular customers' needs," contends analyst Shmuel Halevi of the Technology Research Group in Boston. "But now they can't succeed by just building a better mousetrap."

The new differentiators are old-fashioned concepts such as higher quality, service, support, and on-time delivery. "We've had too much emphasis on algorithms and fundamental core technologies," Cadence Design Systems Inc. president and CEO Joe Costello said in his keynote speech at the Design Automation Conference in June. Calling for a more "balanced" approach by vendors, he cited the need for more support, better documentation and training, and more vendor cooperation, among other changes. "Customers are looking for more complete solutions than ever before. They don't want just little bits and pieces."

The market numbers reflect the customer's dissatisfaction. After years of double-digit growth in the 1980s, the worldwide EDA market grew just 7% to $3.4 billion in 1991, according to the market research firm Dataquest Inc. in San Jose. Although forecasters expect a return to double-digit growth in 1992 due to improving economic conditions and market acceptance of a new generation of products, the temporary lull has put the squeeze on EDA vendors large and small. Costello estimates that net income of EDA vendors has been cut in half since the mid-1980s, down to 2% or 3% after tax for the industry as a whole. "That's more like a grocery industry than high technology," he said. High-flying Cadence's net profit fell to 7.8% of its $171 million in revenue for the first nine months of 1991, from 16.5% last year.

An industry consolidation has been the most striking result of shrinking growth and profits. Acquisitions have occurred at the rate of one a month for the last four years, says Dataquest analyst Ron Collette, including Huntsville, Ala.-based Intergraph Corp.'s purchase of Daisy Cadnetix Inc. in Sunnyvale, Calif. last year and San Jose-based Cadence's merger with Valid Logic Systems Inc., also of San Jose, last October. If the Cadence/Valid merger is completed this month as expected, the new Cadence will emerge as the market leader in EDA software sales with roughly 34% market share, bumping it ahead of long-time leader Mentor Graphics



Laine Enkeis

EDA vendors overemphasized technological innovation at the expense of better customer service and support, admits Cadence CEO Joe Costello

Corp. of Beaverton, Ore., according to Gisela Wilson with International Data Corp. in Framingham, Mass.

ANALYSTS EXPECT the consolidation trend to continue. "Companies that are set up for double-digit sales growth get scared" when growth slows, says TRG's Halevi. "The weaker players look for a way to leave the business profitably, and the stronger players look for acquisitions to gain market share."

Companies intent on surviving also are cutting costs and otherwise restructuring to adapt to the new realities—a sure sign that the EDA industry is approaching adolescence. Mentor Graphics, which lost $62.3 million in the past three fiscal quarters on $293 million in revenue, recently laid off 15% of its staff and scrapped product divisions for computer-aided software engineering and mechanical design to concentrate on its core EDA business. Cadence ordered an unscheduled shut-down in July. Prior to its acquisition by Cadence, Valid—like many old-guard EDA vendors—cut administrative costs and scrapped its low-margin hardware-reselling business. "Anyone can run a company whose revenues are growing at 20% to 30% a year, but that no longer describes the EDA business," says George Klaus, formerly Valid's president and the chief operating officer of Cadence. Upon taking the helm last autumn, Klaus began to restructure the company for less than 10% annual growth.

Nevertheless, managers at Valid, the industry's third-largest player, cited a scarcity of capital as the reason they merged their company's name out of existence. Although Valid recently appeared to overcome years of financial woes—four straight profitable quarters and a spate of multimillion dollar contracts this year—founder Doug Hajjar says, "It was hard to see how we could afford to keep up the pace of R&D investment five years from now." Hajjar will stay on at Cadence as vice chairman.

The long-term answer to improving margins is not cost-cutting, but increasing revenue by finding new competitive advantages that will command higher prices from appreciative customers. With that in mind, market leaders such as Cadence, Mentor, Intergraph's Dazix subsidiary, and Synopsis Corp. in Mountain View, Calif., have announced consulting divisions in the past year designed to make their design management expertise available to customers.

MOST OF THE CREDIT for the vendors' transformation goes to tougher customers, most of which are fed up with the bug-ridden software, serious delays, and the lackadaisical service policies of the past. "Computer-aided engineering is on the critical path of almost everything we do, but we've been living with half-baked tools for too long," says Jean Pierre Braun, who recently left his job as CAE director with Chips & Technologies Inc. in San Jose to join EDA start-up Sunrise Test Systems in Sunnyvale, Calif. "Today, the tools out there are similar enough so that you can put pressure on the vendor to go the extra mile." C&T insists that EDA salesmen leave actual software behind for C&T engineers to test in

the comfort of their own facility instead of being forced to evaluate the system at vendor labs, an unheard of accommodation a few years ago.

The root of that new rebelliousness among customers is simple, explains Bruce Jenkins, an analyst with Daratech Inc. in Cambridge, Mass.: "The mystique has fallen away from EDA." Having witnessed the rise of highly-functional but inexpensive design tools for the PC platform, and the meteoric improvement in the price/performance of commercial PCs and workstations, customers that were dazzled by the $100,000-plus turnkey systems of the early 1980s now see EDA as just another capital-goods purchase where solid service and support are required. "Customers have come to realize that EDA vendors don't have any magic wands," says Jenkins.

Perceiving less value from the vendors' current product lines, customers are less apt to pay top dollar for traditional tools, making the new services a crucial revenue source for the future. Mentor recently set up a 440-person "Customer Success" organization that combines support, training, management consulting, and other services. Customers praise the unit, which has helped Mentor regain much-needed credibility with customers burned by the 12-month-plus delay in the shipment of Mentor's latest version of its software, the Release 8.0 design environment. Ultimately, the unit could contribute 25% or more of total Mentor revenues, predicts systems division president Gerard Langeler.

Mentor's relationship with General Electric Aerospace is at the cutting edge of that more comprehensive approach the industry is taking toward its major clients. With the customer-success organization taking a lead role, Mentor became the primary integrator for EDA systems at GEA in a five year, $25 million-plus deal that began in 1990. Not only did GEA mandate that Mentor integrate the software of seven competing EDA vendors into one company-wide system, but as part of the package also requested that Mentor provide a range of other services—forge licensing agreements with other tool vendors, create training courses, schedule projects, write technical documentation, and customize its off-the-shelf products to work within GEA's existing design methodologies. In all, Mentor has 20 people devoted to the account, with ten on-site at any one time—more than at any other client.

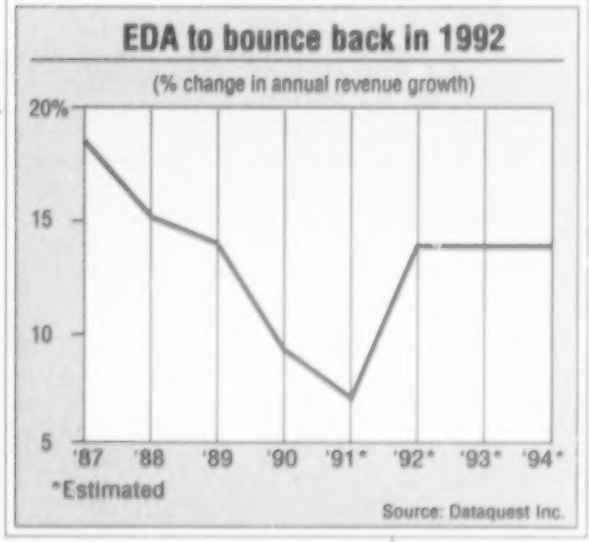
"We knew our product wasn't tested, but we shipped anyway. The customers never said a word"

After a slow start, GEA says it is pleased with the relationship, according to Dave Rollenhagen, manager of GEA's engineering support center in King of Prussia, Penn. The company is on track to reach its goal of improving engineering productivity by 25% by 1993, he says. "I don't think Mentor understood the role of an integrator at first, but it's turning out to be a win-win situation," says Rollenhagen. "We forced it into some new directions, but Mentor has come to realize that a lot of other large companies are going to want similar levels of service."

Partnerships with the customers also help vendors improve their product direction, sometimes even yielding new technologies that can be commercialized. Mentor upgraded its model-library management system based on joint development with GEA. Cadence has expanded its menu of technology development partners with multiyear, multimillion dollar contracts to develop next-generation ASIC design tools with Fujitsu Microelectronics Inc. in San Jose and NEC Electronics Inc. in Mountain View, Calif.

To preserve their viability in a market increasingly dominated by vendors with a broader array of products, a host of small- to mid-size EDA vendors have developed networks of tight marketing agreements with each other or with larger competitors to give them access to customers with broad-line needs. That category includes niche players such as Analogy, Eesof, Logic Modelling Systems, Minc, Synopsis, and Zycad; in many cases, these companies do joint selling on a regular basis.

Service is another area where EDA vendors are trying to improve. While the benefit of pure technology is still the single most compelling reason to buy EDA, the maturing of the market has turned once-mundane factors such as service and support into critical differentiators. "We have been fair as far as service goes, but we need to be more proactive in finding ways to head off customer problems," concedes Lutz Henckels, president of Racal-Redac Inc., a Mahwah, N.J.-based unit of



Britain's Racal Electronics plc. As a start, Henckels recently created the position of "Mr. Corruption," a full-time telephone support specialist whose sole job is to help customers that gum up Racal's new-fangled object-oriented database retrace their steps and clean up their mistakes.

Other vendors are farther along in their efforts to improve service and support. Cadence "used to be absolutely pitiful," says one customer. "Very often we would get stuck in the mud because of some bug and it would just laugh at you, but it has made a lot of progress of late."

Other vendors have changed their ways as well. Viewlogic Systems Inc. in Marlboro, Mass. and Vantage Analysis Systems Inc. in Fremont assign at least one application engineer to each salesman to ensure that customers receive more sophisticated and responsive technical help. Due to the more customer-oriented approach, Viewlogic claims it is on track for 30% revenue growth this year while Vantage expects to grow almost 100%. "We didn't choose Viewlogic because of its tools; we chose it because of its service," says Braun, Chips & Technologies' former CAE manager. "It had applications engineers working in-house with us, and they were very willing to integrate our existing suite of tools into their environment. It has built up a lot of loyalty."

"We've been living with half-baked tools for too long," complains one EDA customer

Central to any notion of top-notch customer service is product quality, an area where EDA vendors have been grossly lacking. "The EDA user has been conditioned to think bugs are a cost of doing business, and the real kick in the teeth is that they get to pay a maintenance fee for the privilege of fixing them," says Wayne Gutschick, president of Colorado Springs-based Minc Inc., a vendor of design tools for programmable logic devices and field-programmable gate arrays. "We knew our first product wasn't well tested when we shipped it in 1988, but we closed our eyes and shipped anyway. You know something? The customers never said a word."

THOSE DAYS ARE COMING to an end, albeit slowly. With total quality management (TQM) in vogue, customers are less accepting of EDA vendors' transgressions. TQM crusader Motorola Inc. recently did a three-day audit of Mentor Graphics's software development. While Mentor didn't flunk the test, the company received the lowest passing grade possible, says a Mentor source.

Some EDA companies are now working to ensure better quality in their products. MINC, with only 40 employees, has invested about 50 man-years to develop automated software test tools that get 98%-plus coverage, says president Gutschick. Cadence devised a seven-dimension quality measuring criteria it calls the IQ system, and plans to pass all products through that comprehensive check before shipping, claims Costello. "Customers are starting to grade software quality just as they do hardware quality, and that is going to be a big competitive advantage for us," he predicts.

If the scores are good, that is. □

Will top-down design reinvigorate EDA?

IT'S BEEN 10 years since EDA pioneers such as Daisy Systems, Valid Logic Systems, and Mentor Graphics began selling electronic tools to do such work-a-day tasks as schematic capture and PCB layout. These tools, which essentially give customers an electronic alternative to pencil and paper, created an industry that has grown to more than $3 billion.

Now a new generation of products is available that changes the electronic design process. It's called top-down design and it promises to let designers describe a product's function—the new-fangled EDA tools determine the actual configuration of gates and circuits. Sales of top-down design tools based on high-level hardware-description languages (HDLs) such as the U.S. Department of Defense-backed VHDL or Cadence Design System Inc.'s Verilog, are expected to far outpace the rest of the EDA market. Revenue from HDL simulators for top-down design are expected to more than triple by 1995, to $245 million, according to the investment-banking firm Wessels, Arnold & Henderson in Minneapolis. The firm predicts that the market for logic-synthesis tools, which translate the high-level descriptions into actual gates and circuits, will grow sevenfold, to $285 million, between 1990 and 1995.

Tools that make concurrent engineering a reality also should foster increased growth. At the heart of that methodology, which speeds time-to-market by enabling engineers from different disciplines to work on a project simultaneously rather than in serial, are frameworks. These are software backplanes that let customers mix and match a range of tools—both in-house and from various vendors—in one tightly integrated design environment.

Until that new generation of products finds their way into the mainstream, however, EDA revenue growth will fall short of traditional levels. "The underlying reason is clear: the 'simple' problems have been solved, but no one knows how to solve the complex problems yet," says analyst with Shmuel Halevi with Technology Research Group in Boston. □

Can plain ol' copper bring fiber performance to the desktop?

If a 100-Mbps can be delivered over ordinary telephone lines, the FDDI market will soar to $1.5 billion

By Dwight B. Davis

Just three years ago, vendors were struggling to transplant the popular 10-megabit-per-second (Mbps) Ethernet local area networking standard from coaxial cable to unshielded twisted pair (UTP) telephone wiring to provide a more cost-effective link between desktop computers. At that time, the 100-Mbps fiber distributed data interface (FDDI) standard was far ahead of the network throughput needs and pocketbooks of most desktop users. The lack of a market stalled product sales for FDDI chip and system vendors such as Advanced Micro Devices, Ungermann-Bass, and Proteon.

Things are changing fast, though. Users' needs for broader bandwidth and higher throughput for image processing, graphics, and CAD/CAM applications has created a huge opportunity for datacom component and system vendors, if they can offer products that support high data rates over inexpensive copper wiring. Vendors are courting the desktop market with a fervor as they eye an installed base of 2 million workstations. A successful demonstration of fiber-like data transmission over copper would help to create a market estimated at $1.5 billion by 1994, according to analysts and vendors.

A copper-based FDDI standard would open up a huge market in two ways—not only are copper-based networks and components less expensive than their fiber counterparts, but the standard would create the opportunity to retrofit hundreds of thousands of workstations on existing networks to handle 100 Mbps. Currently, FDDI vendors struggle with a tiny market supplying components and fiber cabling for backbone links between local area networks and for other niche applications—the worldwide market for FDDI backbones in 1990 was less than 5,000 connections, according to the Gartner Group, a Stamford, Conn.-based research company. Only about 350 FDDI adapters for technical workstations will ship during 1991, estimates Brad Baldwin, an analyst with Gartner's San Jose office.

More than 50 vendors currently sell fiber optic-based interface products to link mainframes, workstations, and other devices to FDDI networks. Among the leading suppliers, according to the Gartner Group, are Sun Microsystems, Digital Equipment, Cisco Systems, Interphase, Fibronics International, and Network Systems.

Crescendo rushed to the non-fiber FDDI market before standards were in place because of user demand, according to company CEO Mario Mazzola

An American National Standards Institute (ANSI) working group charged with developing a standard for 100 Mbps over twisted pair wiring is scheduled to release its specifications by April 1992. The ANSI recommendations will encompass "voice-grade" UTP wiring and higher-quality "datagrade" UTP and shielded twisted pair (STP) wiring. Datagrade media have higher twist rates than voice grade and use higher quality material to encase the copper wiring; these differences improve transmission characteristics and immunity to outside electromagnetic noise. STP media have shielding that contains electromagnetic emissions and confers even better noise immunity.

IN ANTICIPATION OF the ANSI standards, vendors are developing—and in some cases already offering—FDDI adapter cards and central wiring hubs that will support the different types of copper media. The initial market for these products are workstations running applications such as computer-aided design and engineering, imaging, scientific processing, animation, and financial services. Vendors also expect high-end personal computers will need FDDI-type communications bandwidths to

support applications such as multimedia.

Few users have yet connected FDDI links of any type to desktop devices, but a number of companies are investigating the technology. Boeing Computer Services of Seattle, for example, has several experimental versions of desktop FDDI products in its labs, using fiber optic, STP, and UTP adapters. "Before we adopt any new technology, we have to perform a business case analysis that examines end-user requirements, learning and support issues, and price considerations," explains Everett Rigsbee, senior network systems architect within BCS's Network Services and Support group.

Boeing has determined that several workstation applications could readily exploit 100-Mbps data rates. They include CAD/CAE and graphics-intensive "virtual reality" programs, Rigsbee says. Many Boeing buildings have STP wiring installed, while others have datagrade UTP plants. "The ability to add even a small amount of service improvement to the exiting media would represent a big plus to us," Rigsbee says.

Hoping to address such needs, seven vendors have banded together to test various methods for achieving FDDI over UTP. Calling itself the Unshielded Twisted Pair Development Forum (UDF), the group intends to demonstrate the feasibility of the technology soon, says Jayshree Ullal, director of product marketing at Ungermann-Bass Inc. of Santa Clara, Calif., a UDF member. This month, the UDF expects to present a unified proposal to the ANSI working group, recommending a single UTP solution from among the several techniques it has tested.

At least one UDF member isn't waiting for the completion of the forum's testing program, however. In October Crescendo Communications Inc. of Sunnyvale, Calif., announced a family of FDDI products designed to operate over STP, datagrade, and potentially voice-grade wiring. Slated to ship in January 1992, the start-up company's products will use

Emission control poses hurdle for copper

SEVERAL TECHNOLOGICAL hurdles must be jumped to support a 100-Mbps bandwidth on voice-grade unshielded twisted pair wiring. The biggest challenge is controlling electromagnetic interference (EMI). Light-based fiber-optic signals have no such emissions, and STP wiring has shielding that contains them.

The Federal Communications Commission limits EMI radiation for both office (class A) and home (class B) environments. Generally, the FCC restrictions apply to EMI frequencies above 30 megahertz (MHz). A key vendor objective is to build FDDI devices that can meet FCC class A requirements over reasonable distances of voice-grade copper wiring at a modest cost.

For vendors to achieve that goal, they must change the method by which data is encoded for transmission over the network. Standard FDDI encoding—developed for fiber-optic media—sends information at frequencies between 30 MHz to 80 MHz. In addition, repeating data patterns, such as those generated by a station's idle signal, can cause emission spikes.

To combat EMI, vendors propose a two-step solution. First, data to be transmitted is scrambled by an algorithm to eliminate any repeating data patterns and to smooth spikes. The second step is to encode the scrambled data in a way that reduces the transmission's frequency to below 30 MHz.

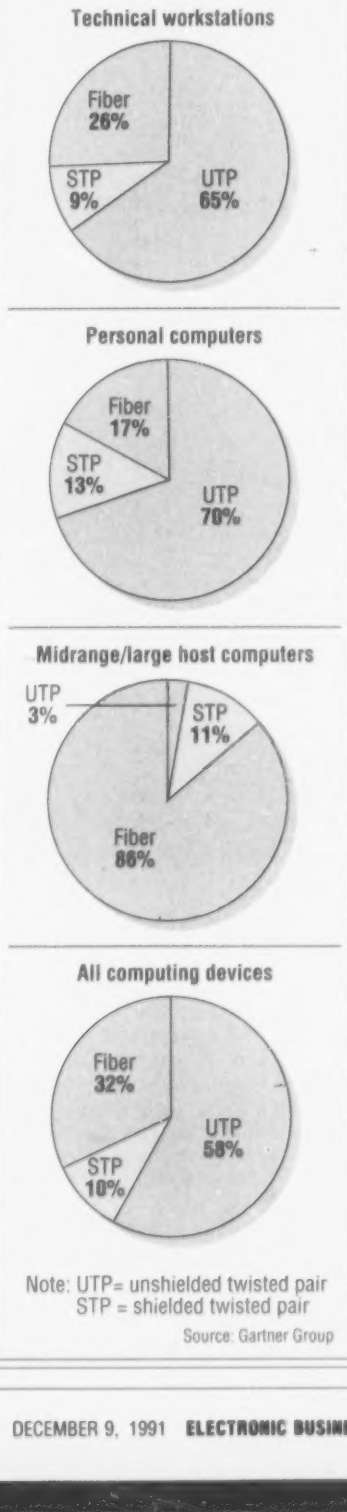
A group of seven companies calling itself the Unshielded Twisted Pair Development Forum (UDF) has been testing different line-encoding techniques to find one that can meet the FCC's EMI requirements and also be cost-effectively built into products. The UDF members are Apple Computer, AT&T Microelectronics, British Telecommunications, Crescendo Communications, Fibronics International, Hewlett-Packard, and Ungermann-Bass.

Only one of the encoding schemes, Carrierless Amplitude/Phase-32 (CAP-32), keeps the entire energy spectrum below 30 MHz. Considered "a powerhouse of a code," CAP-32 has been deployed by the telecommunications industry for years and is supported by AT&T Microelectronics. But CAP-32 is also the most complex of the schemes and potentially the most expensive to implement. UDF member Crescendo Communications already has developed a product line around a competing scheme called Multi-Level Transitional-3 (MLT-3), which, the company maintains, provides adequate FDDI performance over UTP at lower cost.

Another approach to reduce EMI emissions has potentially serious drawbacks. Vendors could reduce the power of the transmission signal and increase the sensitivity (and price) of the receiver, but this solution could limit the distance the signal could travel over UTP before it is overpowered by external noise or "crosstalk." Fiber-optic FDDI links are designed to operate over 100-meter distances, but to balance performance with low cost, future ANSI standards for FDDI over UTP may lower the distance requirement. Even if the distance should be cut in half, though, vendors and analysts agree that a UTP solution would be widely applicable: Up to 95% of employees' desks in offices are within 50 meters of the central wiring closet, according to recent studies. □

Non-fiber media to dominate FDDI market

(% of networked systems using FDDI in 1995)



Note: UTP= unshielded twisted pair
STP = shielded twisted pair

Source: Gartner Group

Don't count fiber out

WITH MUCH OF THE FDDI community focused on achieving 100-Mbps transmission over UTP wiring, it is possible to overlook progress being made to reduce the cost of fiber-based networks. Just as ANSI has a working group developing a proposal for a UTP standard, it also has a working group dedicated to finding less expensive fiber solutions. If the latter group succeeds in its efforts, it could encourage use of fiber-based FDDI and somewhat reduce the market potential of UTP products.

In fact, fiber fans insist that its advantages—EMI immunity and inherently higher capacity than copper—will eventually help fiber-based FDDI to prevail. "People are trying to design networks for next generation speeds such as a gigabit per second," notes Bob Fink, head of networking at Lawrence Berkeley Laboratories and chairman of the low-cost-fiber working group. "The bulk of the market in the long run will be fiber."

To reduce the cost of FDDI fiber networks, the working group is focusing on two key devices: transceivers and connectors. Optical transceivers currently cost $300 to $350 but should drop to $70 to $80 within the next year, Fink predicts. The reduction will occur, in part, because his working group will permit FDDI transmitters to be less powerful and FDDI receivers to be less sensitive.

On the connector front, the group will back either an "ST" or an "SC" design. Each is less expensive than the connectors required by the original FDDI specification. The existing specification is simply "overkill," Fink states.

A potential downside to the fiber-based FDDI cost-reduction efforts is a trade-off in performance capability. "Even if customers go with fiber optic, that won't guarantee that they won't have to compromise in the future," cautions Mario Mazzola, chief executive officer of Crescendo Communications, a recent entrant in the non-fiber-based FDDI market. Despite the cost savings, fiber-based networks should be able to support any foreseeable networking requirements, Fink responds. □

a proprietary data-encoding and scrambling scheme that the company has independently presented to the ANSI committee. Chief executive officer Mario Mazzola claims that Crescendo will offer existing customers a hardware upgrade to achieve ANSI compatibility if that becomes necessary, but he admits that the cost of such an upgrade can't be determined.

Crescendo rushed to the market because many users already are demanding less expensive components to achieve 100-Mbps links between desktop workstations, claims Mazzola. Fiber-optic FDDI adapter cards for workstations typically cost between $5,000 and $12,000, in many cases as expensive as the workstations themselves. One of Crescendo's first products will be a $1,495 UTP-based FDDI adapter card that is compatible with workstations using the Sun Microsystems Inc. S-Bus. Throw in the UTP concentrator module for $900—a workstation in a twisted pair FDDI network must connect to a concentrator or other device that functions as a hub—and the cost per station totals just under $2,500.

Pricing advantages such as these will inspire anywhere from 100,000 to 200,000 workstation owners to quickly move to UTP-based FDDI links, if the vendors' claims of functionality and cost-efficiency are proven, estimates Juan Figueroa, FDDI marketing manager at AT&T Microelectronics' MOS division in Allentown, Penn. By 1993 or 1994, he

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MARKET PERSPECTIVES

adds, the number of workstations with such FDDI links could grow to 500,000 to 750,000. Michael Howard, president of the San Jose-based research firm Infonetics Research Inc., predicts that approximately 500,000 FDDI units of all types will ship during 1994, representing a value of $1.5 billion. More than 60% of these units will be products linking workstations to concentrators, he says, while 40% of the units will represent the more traditional backbone and mainframe type of FDDI applications. Of the workstation-to-concentrator FDDI units, Howard predicts that more than 50% of them will be UTP devices.

Despite the rosy predictions, all parties caution that their estimates assume voice-grade UTP will prove a feasible medium for carrying data at FDDI rates. Although vendors have demonstrated that both shielded twisted pair and datagrade wiring can handle FDDI, questions remain about voice-grade UTP (see "Emission control poses hurdle for copper").

Even if vendors can make FDDI work over voice-grade cable, potential customers won't be able to presume that their existing copper will be up to par. The generic term "voice-grade" encompasses a broad range of wiring types, only a small percentage of which may prove adequate for FDDI's UTP requirements. Because most existing wiring was never graded at the time of its installation, customers will have to test their cables to ensure they comply with any future ANSI standard.

Customers with existing STP wiring face fewer problems, but this type of media is relatively scarce, although five companies—Digital Equipment Corp., Chipcom, Advanced Micro Devices, Motorola, and Synoptics—have a specification for building FDDI adapters that can take advantage of the installed base of STP wiring. "Not a lot of people are beating down our door for STP solutions," concedes Karl Pieper, DEC's FDDI marketing manager. "Everyone wants UTP." □